APPENDIX A

DATA COLLECTION PLAN

COMMERCIAL DEMONSTRATION
OF THE SNOX TECHNOLOGY

DATA COLLECTION PLAN

Ohio Edison Company

Niles Plant

Niles, Ohio

Unit 2

ASEA BROWN BOVERI

Environmental Systems

Birmingham, Alabama

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Revision 5

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INTRODUCTION

The following Primary Objectives for the SNOX Demonstration Project exist to demonstrate and evaluate the performance of this process in a North American high-sulfur coal-fired commercial application.

1. Demonstrate NOx and SO_2 removals of 90 and 95%, respectively.
2. Demonstrate the commercial quality of the product sulfuric acid.
3. Satisfy all Environmental Monitoring Plan (EMP) requirements.
4. Perform a technical and economic characterization of the technology.

The following Secondary Objectives are identified in order to fully establish a basis for the technical and economic evaluation of a commercial application of this technology.

1. Execute parametric test batteries on all major pieces of equipment.
   - Fabric Filter
   - SCR System
   - SO_2 Converter
   - WSA-Condenser
   - Gas/Gas Heat Exchanger
   - Catalyst Screening Unit

2. Quantify process consumptions.
   - Power
   - Natural Gas
   - Catalysts
   - Cooling Water
   - Potable Water
   - Ammonia

3. Quantify process productions.
   - Sulfuric Acid
   - Heat
4. Quantify personnel requirements.
5. Evaluate all materials of construction.

The Data Collection Plan contained in the remainder of this document has been developed for the collection of the data necessary to meet the Primary and Secondary Objectives of the SNOX Demonstration. The Data Collection Plan is divided into individual Test Batteries. Most of the Test Batteries represent parametric studies of a specific aspect of the SNOX Process. All data collected from these Test Batteries will be compiled into a Master Data Base along with any supplemental or additional information.

Each Test Battery has been assigned a priority rating based on its directpertinence to the Demonstrations objectives. Ratings of 1, 2, and 3 are deemed necessary for the fulfillment of these objectives. A priority rating of 4 indicates data that may be of value but is not necessary for the fulfillment of these objectives. Certain situations will release funding which may allow an extended operating period - specifically, if demolition of the plant and site restoration are not required. Priority 4 Test Batteries will be executed should the extended operating period become available.

The predicted time frame and schedule for the execution of the Data Collection Plan is shown in the Appendix.

Where not explicitly stated in the testing description, all test procedures will conform to industry standard testing procedures such as those by EPA, ASTM, EPRI, APHA, AWWA, and WPCF. In addition, all target process parameters must be maintained in a steady fashion for a minimum of one (1) hour prior to any test.

TEST BATTERY NAME: **Automatic/Routine Data Collection**

TEST BATTERY NUMBER: 1

ESTIMATED TESTING PERSONNEL: 0

ESTIMATED TESTING DAYS: 0

PRIORITY: 1

Description

Test Battery 1 consists of the data recorded automatically through the Distributive Control System (DCS), collected routinely through laboratory analyses and logged daily by the Operations Staff. This test battery will be divided into three (3) data groups accordingly.

Data Group 1A - DCS Recorded Data

All information required to monitor the general health and performance of the SNOX Plant is archived through the DCS at 6 minute intervals into a magnetic media data base. The specific parameters recorded are listed in TABLE 1-1. In addition to this recorded data, the DCS will produce, on a continuous basis, a hard copy printout of all operations activities executed through the DCS as well as all trips, alarms, messages and errors that occur during the plant's operation. These printouts will be bound, labeled and stored.

Table 1-1 DCS Recorded Process Variables

Gas Side

1. Inlet Stream Temperature
2. Inlet Stream Pressure
3. Fabric Filter Inlet Temperature
4. Fabric Filter Differential Pressure

Table 1-1 DCS Recorded Process Variables

Gas Side (Cont'd)

5. Fabric Filter Outlet Dust Load
6. Fabric Filter Outlet Temperature
7. Fabric Filter Outlet Pressure
8. Unit 2 Gross Load
9. Demo Plant Gas Flow
10. Flue Gas Booster Fan Amps
11. Booster Fan Totalized Power Usage
12. Booster Fan Discharge Temperature
13. Booster Fan Discharge Pressure
14. Post Fabric Filter SO_2 Concentration
15. Post Fabric Filter NOx Concentration
16. Post Fabric Filter O_2 Concentration
17. GGH Cold Side Outlet Temperature
18. GGH Cold Side Outlet Pressure
19. SCR Inlet Temperature
20. SCR Outlet Temperature
21. SCR Differential Pressure
22. SCR Outlet NOx Concentration
23. SCR Outlet O_2 Concentration
24. Ammonia Mixing Air Flow
25. Ammonia Flow
26. Ammonia/Air Mixture Temperature
27. SO_2 Converter Inlet Temperature
28. SO_2 Converter Inlet Pressure
29. SO_2 Converter Differential Pressure
30. SO_2 Converter Outlet A Temperature
31. SO_2 Converter Outlet B Temperature

Table 1-1 DCS Recorded Proces Variables

<u>Gas Side</u> (Cont'd)

32. SO_2 Converter Outlet C Temperature
33. SO_2 Converter Outlet D Temperature
34. SO_2 Converter Outlet Mixed Temperature
35. WSA-Condenser Inlet Temperature
36. WSA-Condenser Inlet Pressure
37. WSA-Condenser Outlet Temperature
38. WSA-Condenser Outlet Pressure
39. WSA-Condenser Outlet SO_2 Concentration
40. WSA-Condenser Outlet NOx Concentration
41. WSA-Condenser Outlet O_2 Concentration
42. WSA-Condenser Outlet Acid Mist Concentration
43. WSA-Condenser Tube Sheet Differential Pressure
44. Cooling Air Inlet Flow
45. Cooling Air Inlet Temperature
46. Cooling Air Inlet Pressure
47. Cooling Air Discharge Temperature
48. Cooling Air Fan Amps
49. Cooling Air Fan Totalized Power Usage
50. System Outlet Temperature

<u>Acid Side</u>

51. Acid Circulation Pump Inlet Temperature
53. Dilution Water Flow Rate
54. Dilution Water Totalized Flow
55. Cooled Acid Temperature
56. Product Acid Flow

Data Group 1B - Routine Analyses

Routine analyses of the inputs and outputs of the process will be made and their results compiled into the Master Data Base. TABLE 1-2 shows the parameters that will be tested, the analytical methods to be used, and the frequency of each test.

Table 1-2 Routine Analyses

Stream	**Parameter**	**Method**	**Frequency**
Coal			
	H_2O,Ash,S,Btu/lb	Proximate	Daily (5)
	C,H,N,O	Ultimate	Monthly
	Trace Elements (1)	(2)	Quarterly
	Cl,F	(2)	Quarterly
Product Acid			
	wt.%	Titration	Each Load
	Color	APHA Standards	Each Load
	Fe	(2)	Each Load
	Trace Elements (1)	(2)	Monthly
	Cl,F	(2)	Monthly
	SO_2,NO_3,NH_4	(2)	Monthly
	SiO_2	(2)	Monthly
Flyash			
	Trace Elements (1)	(2)	Quarterly
Catalyst Siftings			
	Heavy Metals	EP Toxicity	Each Occurrence
	Heavy Metals	TCLP	Each Occurrence
	Trace Elements (1)	(2)	Each Occurrence

(1) Trace Elements defined as As, B, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Se, V, Zn. Should certain elements prove nonexistent or undetectable, they will no longer be tested for.

(2) Best Available Method

(3) Ion Specific Electrode Method

(4) Ion Chromatography

(5) This data is generated daily by Ohio Edison and is not the responsibility of the Testing Contractor.

Data Group 1C - Operator Logged Data

In addition to maintaining detailed documentation of the plant's operation, operators will collect and log certain data manually. This data will be merged into the Master Data Base. The minimum data points that will be logged once each shift by the SNOX Plant Operations Staff are listed in TABLE 1-3. The minimum data points to be logged by the Ohio Edison Main Control Room Operators are listed in TABLE 1-4.

Table 1-3 Operator Logged Data (By SNOX Plant Operators)

1. SNOX Plant Totalized Power Usage
2. SNOX Plant Instantaneous Power Demand
3. Totalized Natural Gas Feed Flow
4. Totalized 1st Support Burner Natural Gas Flow
5. Totalized 2nd Support Burner Natural Gas Flow
6. Totalized 3rd Support Burner Natural Gas Flow
7. Quantity NH_3 Loaded from Supply Trucks

Table 1-3 Operator Logged Data (By SNOX Plant Operators)(Cont'd)

8. Quantity H_2SO_4 Distributed to Transport Trucks
9. Acid Cooling Water Inlet Temperature
10. Acid Cooling Water Outlet Temperature

Table 1-4 Operator Logged Data (By Ohio Edison Operators)

1. Unit 2 Gross Power Production
2. Unit 2 Net Power Production
3. Unit 2 Auxiliary Power
4. Unit 2 Boiler O_2
5. Unit 2 Cyclones In Service
6. Unit 2 Fuel Flow

TEST BATTERY NAME:	**Baseline Testing**
TEST BATTERY NUMBER:	2
ESTIMATED TESTING PERSONNEL:	1 to 4
ESTIMATED TESTING DAYS:	2A-3, 2B-8, 2C-15
PRIORITY:	1

Description

Test Battery 2, Baseline Testing, will encompass manual testing for the characterization of the existing Unit 2 process streams, calibration/ verification of all instruments, and initial evaluation of the as-installed performance of all equipment. These individual test groups will be identified as 2A, 2B, and 2C, respectively.

Test Group 2A - Unit 2 Characterization

Either prior to operation of the SNOX Demo Plant or with the Demo Plant off-line, this test group will be executed to characterize the existing Unit 2 ESP inlet (Test 2A-1) and stack flue gas (Test 2A-2) streams. These tests will allow the demonstration of the project's impact on pre-existing pollutant generation rates and the verification of the Demo Plant's inlet design parameters. TABLE 2-1 identifies the parameters that will be tested at each location and the methods to be used.

Table 2-1

Test Group 2A-x - Unit 2

Parameter	Measured Unit	Test Method
Flow	ACFM	EPA Method 1 and 2
Temperature	°F	EPA Method 1 and 2
Particulate	gr/DSCF	EPA Method 5 or 17
Particulate	Size Distribution	Cascade Impactors

Total Pressure	in.w.c.	EPA Method 1
SO_2, SO_3	ppm	MACS (1)
NO, NOx	ppm	EPA Method 7E (2)
N_2O, $N0_2$	ppm	(3)
O_2,CO_2,CO,H_2O	%	(3)
HCl,F,NH_3	ppm	ISE or IC
As, B, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Se, V, Zn	ppm	(4)

(1) Miniature Acid-Condensation System

(2) Chemiluminescence Type

(3) Best Available Method

(4) EPA Multiple Metal Train with Appropriate Sample Analysis

The tests in TABLE 2-1 will be performed with Unit 2 at steady full load. Each test will be performed in triplicate and the results averaged. All boiler and precipitator operating data will be logged at thirty (30) minute intervals throughout this test group. The tests common to both inlet and outlet will be performed simultaneously.

Test Group 2B - Monitor Calibrations

2B-1: Baghouse Outlet Dust Monitor

With the SNOX plant at full steady load, the baghouse outlet dust loading will be measured via EPA Method 5 or 17 in duplicate. The results of this test will be used to calibrate/verify the Baghouse Outlet Dust Monitor. (See Test 2C-1)

2B-2: Venturi

Flue gas flow through the venturi will be measured with EPA Methods 1 and 2 at three different load points - 50%, 80%, and 110%. This data will be used in conjunction with recorded venturi signals during the test to generate an operating curve for the venturi. This curve will be used in the DCS to calibrate the venturi signal. A 5-hole pitot tube will be used for this test to limit inaccuracies due to excessive yaw and/or pitch in the flue gas.

2B-3: CEMS

Each of the three (3) CEMS monitoring locations will be traversed for SO_2, NOx, and O_2 with MACS and EPA Methods 7E (Chemiluminescence) and 3A in order to verify the calibration of the CEMS. The MACS tests will also yield acid mist concentration which should be recorded. The acid mist concentration at the outlet point will be used to calibrate the Acid Mist Monitor. The midpoint (post-SCR) testing will be used to evaluate the accuracy of the single point CEM sample probe. If it is found not to be accurate, an action plan for upgrading to a sampling grid will be generated.

The midpoint location will be traversed in triplicate while the inlet and outlet locations will be traversed twelve (12) times in order to follow the EPA certification procedure for CEM's.

2B-4: Acid Concentration Monitor

With the acid circulation system at steady state and normal operating temperatures, a sample of acid will be taken and titrated to determine weight percent sulfuric acid. The result will be used to calibrate/verify the acid concentration monitor. This test will be performed at three (3) different acid concentrations - 93.2, 93.7 and 94.2 wt.%. The temperature compensation for this device will be adjusted as necessary during this calibration.

Test Group 2C - General Equipment Performance

Test Group 2C will be executed in order to evaluate the as-installed performance of each major piece of equipment. The results of these tests will be used to document any changes in equipment performance over time and to verify that all vendor performance guarantee points can be achieved. A main objective of this test group will also be to identify and correct any weaknesses in the process prior to continuing with the Data Collection Plan.

2C-1: Baghouse

At full load, the outlet of the baghouse will be tested with EPA Method 5 or 17 to determine the baghouse outlet dust loading. This test will be performed in duplicate. The data for outlet dust loading should be used for Test 2B-1 to calibrate the Baghouse Outlet Dust Monitor. Due to the expected low dust concentration leaving the baghouse, each outlet particulate test will be sampled over eight (8) hours. Inlet and outlet O_2 measurements will also be taken to assess the quantity of baghouse in-leakage.

2C-2: Gas/Gas Heat Exchanger

This test will be executed in order to verify the heat transfer and pressure drop characteristics of the GGH as predicted by the manufacturer. This test sequence will consist of two (2) sets of simultaneous traverses for temperature, total pressure, and velocity of the inlet and outlet of the cold side and then the hot side of the GGH at three (3) different loads (50%, 100%, and 115%). Each probe used for traversing will consist of an S-tube, a thermocouple, and a Kiel Probe mounted on one (1) conduit. Steady load and temperature conditions will be maintained for one (1) hour prior to each test. For all tests the cold side inlet and the hot side inlet temperature will be 407°F and 796°F, respectively.

The following results will be generated for each load condition:

- average temperature and pressure changes for both sides of the GGH
- inlet and outlet temperature profiles for both sides of the GGH
- inlet and outlet velocity profiles for both sides of the GGH.

2C-3: Selective Catalytic Reactor (SCR)

The results of this test will be used to determine the trimming required for proper operation of the Ammonia Injection System. At steady, full load the outlet of the SCR will be traversed for NOx, NH_3 and velocity in duplicate. Also, the SCR Inlet (pre NH_3 injection) will be traversed for NOx and velocity in duplicate. The resultant profiles will identify any maldistributions of NH_3 or flue gas passing through the SCR and allow for the proper trimming of the NH_3 injection grid. This test can be done simultaneous with the calibration of the midpoint NOx CEM analysis point in Test 2B-3.

The NOx destruction efficiency of the un-trimmed SCR system will be determined and a plan for performance improvement generated. Trimming of the NH_3 injection grid will require a short plant outage.

2C-4: SO_2 Converter

The baseline testing required for the SO_2 Converter will identify the inlet temperature and velocity profiles and allow the balancing of flue gas flow through the four (4) catalyst panels of the vessel. At full, steady load the Converter inlet will be traversed in duplicate for temperature and velocity via the five (5) inlet test ports supplied. This will indicate any thermal or flow maldistribution from the 2nd Support Burner (H-207). The left-right distribution of flow through the vessel will be balanced by modulating the four (4) outlet dampers. Depending on the degree of maldistribution, the traverses may be repeated until proper left-right distribution is attained.

2C-5: WSA-Condenser

The baseline testing for the WSA-Condenser involves the determination of the Condenser's SO_3 collection efficiency and heat transfer coefficient and the identification of any distribution problems with either the flue gas or cooling air. To accomplish this, each of the ten (10) flue gas outlet ducts (2'4" I.D.) of the Condenser will be traversed for flow, temperature, O_2,SO_2, and SO_3 in duplicate at full, steady load. EPA Methods 1 and 2 will be used for flow and temperature while the MACS procedure will be used for $SO_2$and SO_3. O_2 will also be measured at the Condenser gas inlet for air leakagecalculations. During these tests, the cooling air flow, inlet and outlet temperatures and Condenser inlet and outlet temperatures will be logged.

2C-6: Acid Circulation Pumps

The as-installed performance of each acid circulation pump will be documented and evaluated by recording acid flowrates at three (3) pump discharge pressures. This data will be compared to the vendor supplied pump curves. A discharge pressure gauge and acid flow meters are provided in the system.

2C-7: Acid Cooler

The inlet and outlet temperatures of the shell and tube sides of the acid cooler will be recorded at three (3) steady operating conditions. Thisdata will be used to calculate an overall heat transfer coefficient and verify the manufacturer's predicted performance. All these temperatures are provided by process instrumentation.

2C-8: Flue Gas Booster Fan

The initial performance of the Flue Gas Booster Fan will be documented and evaluated by comparing pressure increase across the fan, the flow through the fan, and the horsepower required by the fan at three (3) different loads to the vendor supplied performance curves. All data required can be obtained from process instrumentation. This test should be done simultaneously with the GGH Baseline Test (2C-2).

2C-9: Cooling Air Fan

The Cooling Air Fan performance will be evaluated as described in 2C-8. This test should be done simultaneously with tests 2C-8 and 2C-2.

TEST BATTERY NAME:	**System Performance Analysis**
TEST BATTERY NUMBER:	3
ESTIMATED TESTING PERSONNEL:	4
ESTIMATED TESTING DAYS:	3A-10, 3B-10, 3C-10
PRIORITY:	1

Description

The purpose of the System Performance Analysis is to document the as-designed, as-installed performance of the plant after any initial equipment weaknesses have been corrected. This test battery basically involves monitoring of the process inlet and outlet streams at three (3) different load points.

Test Method

At 75, 100, and 110% of design load (tests 3A, 3B, and 3C, respectively), the inlet and outlet streams of the SNOX Plant will be simultaneously monitored, in triplicate, for the following parameters:

Parameter	Method
Flow, temperature, total pressure	EPA 1 & 2
SO_2, SO_3	MACS
NO, NOx	EPA 7E
N_2O, NO_2	Best Available
O_2, CO_2, CO, H_2O	Best Available
Particulate	EPA 5 or 17
HCl, F, NH_3	ISE or IC

In addition, during Test 3B, the particulate and gaseous components of the plant inlet, plant outlet and fabric filter outlet streams will be analyzed for As, B, Cd, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, Pb, Se, V and Zn via the EPA Multiple Metal Method in duplicate. This information, along with analyses of the coal, product acid, and dilution water will allow mass balances around the process to be made for each of these elements. It is anticipated that the system outlet particulate loading will be very low, thus, the outlet particulate tests will only be sampled for a minimum of eight (8) hours.

Calculated Results

This test battery will primarily yield the system removal efficiencies of SO_2 and NOx at varying loads. Other results will include verification of a system sulfur balance and quantification of NH_3 and SO_3 emissions.

In addition, the inlet and outlet pressures to the Flue Gas Booster Fan will be monitored and recorded during the total pressure traverses in order to verify predicted pressure drops through the system. The NOx generation by the 3rd Support Burner will be documented by recording the WSA-Condenser outlet NOx concentrations from the CEM during the manual NOx tests of the plant outlet stream.

TEST BATTERY NAME:	**Fabric Filter Parametric Study**
TEST BATTERY NUMBER:	4
ESTIMATED TESTING PERSONNEL:	4
ESTIMATED TESTING DAYS:	4A-3, 4B-3, 4C-3
PRIORITY:	2

Description

This Test Battery will be executed in order to characterize the performance of the fabric filter. The filter will be tested for particulate collection efficiency, at three load points. This battery should be executed simultaneously with the particulate testing of Test Battery 3.

Test Method

This battery will involve three (3) tests at 75, 100, and 110% load (4A, 4B, and 4C, respectively). Each test will consist of two (2) fabric filter outlet particulate tests. Each outlet test will occur over an eight (8) hour period. Two (2) fabric filter inlet particulate tests will be performed during each outlet test. EPA Method 5 or 17 will be used. Inlet and outlet O_2 readings will also be taken during each test for leakage calculations. Design process temperatures will be used for all tests in this battery.

Calculated Results

The results of these tests will be inlet and outlet dust loading and removal efficiency for the fabric filter. Throughout the above testing, the Fabric Filter Outlet Dust Monitor readings will be recorded. A graph correlating fabric filter outlet dust load and the Monitor's output signal will be generated.

TEST BATTERY NAME: **SCR System Parametric Study**

TEST BATTERY NUMBER: 5

ESTIMATED TESTING PERSONNEL: 2-4

ESTIMATED TESTING DAYS: 5A-10, 5B-10, 5C-10, 5D-10, 5L-3, 5S-2

PRIORITY: 2

Description

This test battery will be executed to characterize the SCR System which includes the SCR vessel and the ammonia injection apparatus. The Ammonia/Flue Gas Injection System trimming procedure developed from Test 2C-3 should be performed prior to this test battery.

Test Method

This test battery is divided into four (4) main test groups (5A, 5B, 5C, and 5D) which are identical with the exception that they will be executed periodically during the Test Program in order to quantify catalyst reactivity degradation. Test Group 5D will be conducted at the end of the extended program. SCR and system NOx removal efficiences will be determined as a function of NH_3 stoichiometry. NH_3 slip will not be measured.

Each test in the test matrix below will be performed after the designated conditions have been held steady for at least two (2) hours. The SCR and system NOx removal efficiencies and the SCR NH_3 slip will be measured foreach test condition in duplicate. The plant's inlet and outlet CEMS will be used for system NOx removal calculations if the monitoring points have been determined, during baseline testing, to be accurate. Otherwise, manual traversing (also with a CEM) will be required. The SCR outlet will be manually traversed for NH_3 and NOx during each test.

Test I.D.	Load, % Design	SCR Inlet Temp. (°F)	NH_3:NOx Ratio
5x-1	100	715	0.90
5x-2	100	715	0.95
5x-3	100	715	0.98
5x-4	100	715	1.00
5x-5	100	715	1.02
5x-6	100	715	1.05
5x-7	100	715	1.10

Additional Tests

One test in each of the 5A, B, and C series was conducted using point by point ammonia analysis. This was done for the 100% load tests at 1.02 stoichiometry. The purpose was to futher quantify the effectiveness of the ammonia distribution across both dimensions of the SCR catalyst.

To quantify the degree of SO_2 oxidation across the SCR, Test Group 5S will be executed. This test will consist of simultaneous traverses of the inlet and outlet of the SCR using MACS, in duplicate, to yield inlet and outlet SO_2 and SO_3 concentrations. This test will be performed at normal operating conditions.

During outage inspections of the SCR vessel and at the end of the extended program, SCR catalyst samples which have been previously mounted in the SCR, will be removed and returned to Haldor Topsoe, the catalyst manufacturer, for analysis.

TEST BATTERY NAME:	**SO_2 Converter Parametric Study**
TEST BATTERY NUMBER:	6
ESTIMATED TESTING PERSONNEL:	0-2
ESTIMATED TESTING DAYS:	6A-6, 6B-6, 6H-2,6L-14, 6T-4
PRIORITY:	2

Description

Test Battery 6 will characterize the SO_2 oxidation efficiency of the SO_2 Converter. In addition, tests will be run to quantify the results of low temperature and high dust operation. A thermal characterization of the Converter's beds will also be made.

Test Method

This test battery will consist of two (2) main test groups - 6A and 6B. Groups 6A and 6B will be identical with the exception that A will be performed early in the test program and B will occur late in the program. This will identify any catalyst activity degradation. Both tests 6A and 6B will be performed with clean catalyst.

These test groups are comprised of the test conditions identified below in the Test Matrix. Each test will be performed after the designated conditions have been held at steady state for at least two (2) hours. CEMS data, if determined to be accurate, will be used to collect plant inlet and outlet SO_2 concentrations over a two (2) hour period for each test.

Test Matrix

Test I.D.	Load, % design	Inlet Temp. (°F)
6x-1	100	775
6x-2	100	770
6x-3	100	745
6x-4	100	715
Test	Load,	Inlet

I.D.	% design	Temp. (°F)
6x-5	80	800
6x-6	80	770
6x-7	80	745
6x-8	80	715
6x-9	110	800
6x-10	110	770
6x-11	110	745
6x-12	110	715

Should the testing period be extended, a Test Group 6C will be added to furthur identify oxidation catalyst activity degradation. This test group will only be performed at 100% load, i.e. tests 6C-1 through 6C-4.

Additional Tests

In order to evaluate the effects of a high pressure drop/high dust collection situation on catalyst performance, Test Group 6H will be executed. These tests will occur immediately preceding a screening (maximum pressure drop) using the same method described for 6A and 6B. The conditions for these test are presented below:

Test I.D.	Load, % design	Inlet Temp. (°F)
6H-1	100	800
6H-2	80	800

Test Group 6T will characterize the thermal nature of the SO_2 Converter by collecting temperature traverse data for the Converter's inlet, outlet and beds at four (4) test conditions. Two (2) thermowells are provided in each of the eight (8) beds of the Converter. These tests will be performed at the same conditions as and immediately following tests 6A-1, 6A-3, 6A-5, and

6A-7. These test conditions are repeated below.

Test I.D.	Load, % design	Inlet Temp. (°F)
6T-1	100	800
6T-2	100	745
6T-3	80	800
6T-4	80	745

Samples of the SO_2 catalyst will be collected systematically during the screening procedures to be analyzed by the catalyst manufacturer, Haldor Topsoe. A catalyst sample will also be taken at the end of the extended program and returned to Haldor Topsoe for activity analysis.

TEST BATTERY NAME: **WSA-Condenser Parametric Study**

TEST BATTERY NUMBER: 7

ESTIMATED TESTING PERSONNEL: 2

ESTIMATED TESTING DAYS: 7A-7, 7L-3, 7H-2

PRIORITY: 2

Description

Test Battery 7 will be used to characterize the performance of the WSA-Condenser with respect to SO_3 condensation efficiency, H_2SO_4 mist carryover, and product acid quality.

Test Method

After the process conditions for a given test have been steady for at least two (2) hours, two (2) sets of WSA-Condenser outlet manual tests for SO_2 and SO_3 concentration will be performed. The procedure used will be the Miniature Acid-Condensation System or MACS. Each MACS will be run for a minimum of one (1) hour. CEMS SO_2 and O_2 data and mist concentration analyzer data will be collected and correlated with the manual data for verification. Toward the end of each test a sample of Condenser outlet acid will be collected and analyzed for concentration.

The following Test Matrix will be used for Test Group 7A which will vary load and outlet flue gas temperature while holding inlet flue gas and cooling air temperatures at normal values.

Test Matrix

	Flue Gas	
Test I.D.	Load, % Design	Outlet Temp. (°F)
7A-1	60	200
7A-2	60	212

7A-3	60	230
Test I.D.	Load, % Design	Outlet Temp. (°F)
7A-4	80	200
7A-5	80	212
7A-6	80	230
7A-7	100	200
7A-8	100	212
7A-9	100	230
7A-10	110	200
7A-11	110	212
7A-12	110	230

Additional Tests

The effects of cooling air temperature on WSA-Condenser performance will be studied with Test Group 7H. These tests will include high temperature differences between the cooling air and the flue gas outlet. The same test method described above will be used for the following conditions. Normal flue gas inlet and outlet temperatures will be used. Note that this test group will require winter ambient conditions.

		Air
Test I.D.	Load, % Design	Inlet Temp. (°F)
7H-1	100	50
7H-2	100	30
7H-3	100	(minimum)

Calculated Results

Throughout this test battery, inlet and outlet temperatures, pressures and flows for both the shell and tube sides of the WSA-Condenser will be recorded in order to characterize performance with respect to the overall heat transfer coefficient and pressure drops. In addition, acid dilution water flow, product acid flow, and product acid concentration will be monitored.

TEST BATTERY NAME: **Catalyst Screening System Study**

TEST BATTERY NUMBER: 8

ESTIMATED TESTING PERSONNEL: 1

ESTIMATED TESTING DAYS: 30

PRIORITY: 3

Description

Test Battery 8 will be used to evaluate the commercial practicality of the Catalyst Screening System. The SO_2 Converter catalyst will be screened approximately three (3) times over the course of the test program.

The screening frequency for this test battery is estimated based on predicted ash loadings exiting the fabric filter and on pilot plant data. Should the pressure drop of the SO_2 Converter never increase to a level requiring screening of the oxidation catalyst, four (4) of the eight (8) catalyst beds will be screened regardless. This will serve to prove the viability of the screening procedure and equipment and provide adequate data for their evaluation. This will also provide enough siftings material to demonstrate that reclamation of this waste stream is practical.

Test Method

The test method used for this battery is merely a documentation of key parameters and milestones during each execution of the screening process. The information documented will include the following:

- time to preheat screening equipment
- time to transfer catalyst vessels to and from various locations
- time to empty, screen and replace the catalyst for one (1) bed
- time to empty, screen and replace the catalyst for the entire reactor
- time to purge the screening equipment
- effectiveness of the screening process

- mass of catalyst siftings collected during screening
- mass of makeup catalyst addedto each bed
- equipment suitability

The documentation of the screening procedures will be sufficiently detailed to allow optimization of the equipment supplied, optimization of sifting efficiency vs. abrasion loss, quantification of catalyst losses, evaluation of the time required to screen vs. personnel learning curve, and evaluation of system's potential for automation.

In addition to this documentation of the screening procedure, samples of the SO_2 catalyst will be collected during each screening according to a plan to be developed.

TEST BATTERY NAME:	**Optimized System Tests**
TEST BATTERY NUMBER:	9
ESTIMATED TESTING PERSONNEL:	0
ESTIMATED TESTING DAYS:	0
PRIORITY:	3

Description

The Optimized System Tests will be run over a two (2) month period. The purpose of this test is to incorporate any optimization to equipment or operating parameters that has resulted from the previous parametric studies and demonstrate the highest system performance possible (Test Group 9A). Another purpose of this test battery will be to demonstrate the load following capability of the process (Test Group 9B).

Test Procedure

The only testing that will occur during this test battery is the Automated and Routine Data Collection described in Test Battery 1. Plant wide energy and material balances will be performed to verify data quality and value.

Test Group 9A will be executed over a one (1) month period with the Demo
Plant load controlled to 100% of design capacity. During Test Group 9B, however, the Demo Plant load control will be set to track the Unit 2 boiler load or forced into various load change cycles. This Test Group will consist of the following test conditions.

Test I.D.	Test Name	Test Duration	Test Description
9B-2	Low Load	1 week	The SNOX Plant will operate at steady minimum load (30%).
9B-4	Quick Stop/Trip	1 day	The SNOX Plant will be forced through various trip cycles and quick load losses (20%/min).

TEST BATTERY NAME:	**Supplemental Data Acquisition**
TEST BATTERY NUMBER:	10
ESTIMATED TESTING PERSONNEL:	2-4
ESTIMATED TESTING DAYS:	10A-20, 10B-10
PRIORITY:	2

Description

The Supplemental Data Acquisition Test Battery will consist of two (2) separate one (1) month testing periods for the purpose of filling any gaps in the original test plan, collecting any missed test points, and supplying information needed to satisfy the EMP. Also, any supplemental data to the initial core test plan that is determined to be potentially beneficial to the understanding or optimization of this process will be collected during the two (2) test groups (10A and 10B) of Test Battery 10. The majority of the work to be performed is identified below.

Tests 10A-2 and 10B-1 will consist of a re-execution of Test Group 3B for purposes of supplying required EMP information.

Monitor and instrument calibrations will be performed during this test battery as necessary.

Should the testing period be extended, the following tests will be added for supplemental data collection:

10C-1	Repeat of 3B for EMP purposes,
10C-2	WSA cooling air flow boundary identification,
10C-3	WSA cooling air temperature traverse, and
10C-4	WSA flue gas pressure drop measurement.

TEST BATTERY NAME: **High Dust Operation**

TEST BATTERY NUMBER: 11

ESTIMATED TESTING PERSONNEL: 2

ESTIMATED TESTING DAYS: 10

PRIORITY: 4

Description

Test Battery 11 is designed to simulate the operation of the SNOX process with lower efficiency particulate collection devices upstream of the process block. High dust operation will span one (1) month with one (1) dust load being monitored.

Test Procedure

Process block inlet dust loading will be increased by installing a limited number of lower efficiency bags in the fabric filter. This will require a short outage period. The fabric filter outlet will then be tested via EPA Method 5 or 17 in duplicate to identify the process block inlet loading. A loading of 15 mg/Nm^3 will be targeted . The plant will be operated at full load under these conditions until the SO_2 Converter reaches the maximum pressure drop and requires a screening. The fabric filter outlet loading will be verified each week via EPA Method 5 or 17 in duplicate.

Results

Throughout the one month of high dust operation, the SO_2 Converter pressure drop, product acid purity, and system SO_2 removal efficiency will be closely monitored and correlated to dust load.

These results will allow prediction of SO_2 catalyst screening frequency vs. dust load and identification of any side effects to high dust operation such as impure acid or reduced SO_2 removal.

TEST BATTERY NAME: **Alternative Equipment Demonstration**

TEST BATTERY NUMBER: 12

ESTIMATED TESTING PERSONNEL: 2

ESTIMATED TESTING DAYS: 10

PRIORITY: 4

<u>Description</u>

For a one (1) month period toward the end of the project, some products and/or equipment used in the plant will be modified or replaced with alternatives. This will be done in order to identify any possible improvements to performance, reliability, or installed cost through the use of alternative designs or equipment.

The specifics of this test battery are undefined at this time, however, some areas that will be examined are listed below.

12D: Nuclei Injection

Modifications will be made to the nuclei injection method and location.

12E: Acid Storage Tank

For a period of time, the product acid will be stored in the unlined off-spec acid storage tank in order to quantify the degree of iron contamination that will occur.

12F: Acid Characterization and Treatment

A characterization of trace impurities in the product sulfuric acid relative to commercially accepted specifications will be performed. Should any excessive levels of trace impurities be detected on a consistent basis, various methods of treatment or remediation will be investigated and tested.

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TEST BATTERY NAME: **Materials Performance Documentation**

TEST BATTERY NUMBER: 13

ESTIMATED TESTING PERSONNEL: 1

ESTIMATED TESTING DAYS: 15

PRIORITY: 1

Description

Before and after the test program and at each scheduled outage as shown on the Data Collection Schedule, a complete photographic documentation and evaluation of the plant as a whole and specific areas of interest will be made. Still photography and video taping will be used.

The purpose of this photographic documentation is to identify/record the occurrence and progression of wear and corrosion throughout the plant. This documentation will not only apply to the as-designed materials of construction, but will also include test coupons placed in several areas of the plant where the operating environment is considered extreme. Test coupon racks will be placed in the following areas:

- WSA-Condenser Flue Gas Outlet (low temp.)
- Acid Holding Tank

These test coupons will be analyzed at the end of the test program to determine corrosion rates of the various materials in these environments.

Specific areas which must be completely documented are:

- Slipstream takeoff duct
- 1st burner discharge zone
- Clean side of each fabric filter compartment
- Inlets and outlets of the cold and hot sides of the GGH
- NH_3 injection grid

- SCR inlet, outlet, and catalyst beds
- 2nd burner discharge zone
- WSA-Condenser inlet duct, acid basin, shell side, and discharge hoods
- 3rd burner inlet and discharge zones
- Interiors of Acid Holding, Storage A, and Storage B tanks
- Shell side and tube side inlets and outlets of the acid cooler
- Acid containment areas
- Catalyst screening equipment

In addition, all maintenance involving the dismantling of equipment will be photographically documented.

TEST BATTERY NAME:	**Continuous Operation**
TEST BATTERY NUMBER:	14
ESTIMATED TESTING PERSONNEL:	0
ESTIMATED TESTING DAYS:	0
PRIORITY:	4

Description

At various times during the testing period, either scheduled or in the interim between other planned tests, the SNOX Demonstration Plant will be operated near design conditions in a continuous operation mode.

The automatic/routine data collection described in Test Battery 1 will be the only testing executed during these times.